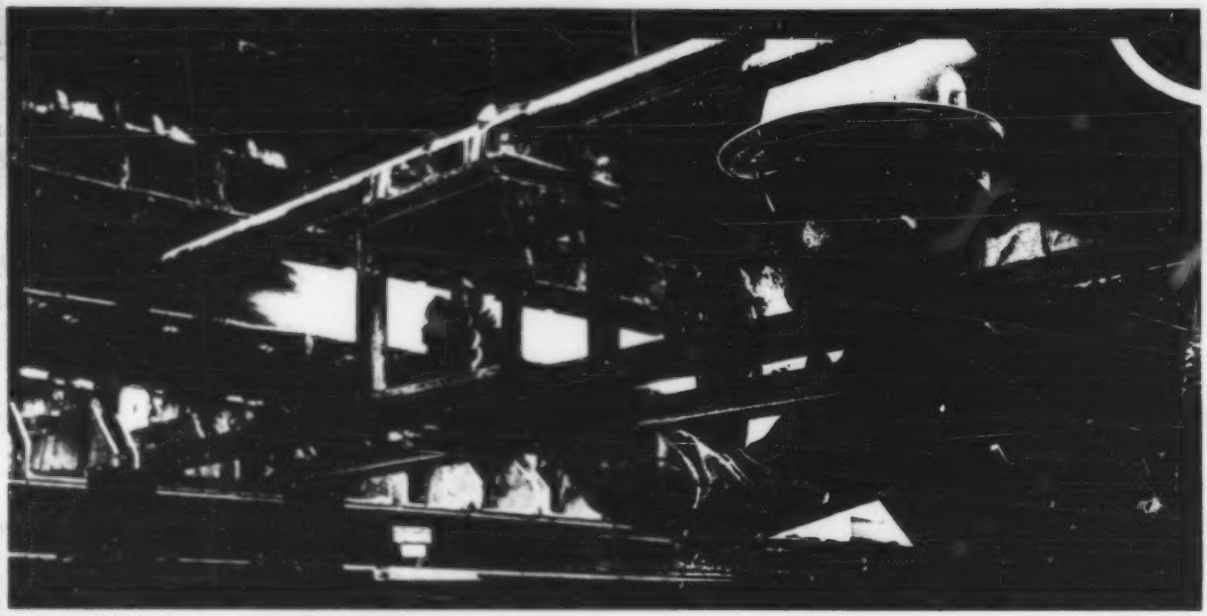
CANMET IN PARTNERSHIP WITH INDUSTRY



ENERGY RESEARCH LABORATORIES
ANNUAL REVIEW

1988-89

RECOVERY

UPGRADING

CATALYSIS

COMBUSTION

CARBONIZATION

COPROCESSING

GASIFICATION

CONSERVATION

Canada

THE ENERGY OF OUR RESOURCES

THE POWER OF OUR IDEAS

ERL'S MISSION

92-01693/

- *increase productivity and enhance competitiveness of Canada's coal, oil and gas industries*
- *improve the environmental acceptability of energy processes and industrial health and safety*
- *support federal policy initiatives for long-term energy security*

Energy Research Laboratories, Bells Corners Complex

Cover photo: ERL's pilot-scale flame tunnel furnace.

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DIRECTOR'S MESSAGE

The Energy Research Laboratories (ERL) has achieved significant success in the past year. We have initiated cooperative new programs with the oil and gas industry for upgrading heavy oils, hydrotreating synthetic crudes, and converting natural gas to liquids. This is directly in line with ERL's major goal to increase our commercially oriented R&D in partnership with industrial clients. The aims of our research at ERL are to minimize the high risks associated with promising new technologies in their early development stages and to transfer these technologies to industry for commercialization in Canada. In the coming year we expect to develop more opportunities to expand our cooperation with industry throughout Canada's energy sector.

The major challenge facing us at ERL is to integrate our efforts with those of industry without losing sight of the need to advance technology. Industry is profit-driven. Profits are usually made by exploiting rather than by generating new technology. In the world of commerce it is often difficult to justify the adoption of technologies that have not been demonstrated to be profitable. ERL's role is to participate with industry in choosing and developing technologies that are ripe for exploitation.

ERL's program and its interaction with industry are influenced strongly by public concern over the environment. Emission of particulates from coal combustion was the first environmental issue in the use of fossil fuels. More recently, interest has focused on emissions of the acid rain precursors, sulphur and nitrogen oxides, from all uses of fossil fuels. The containment of atmospheric pollutants as wet or dry solids has given rise to public concern over the disposal of solid wastes. ERL's programs have addressed all these issues in the past and will continue to do so.

Today, world-wide concern over global warming, the 'greenhouse effect', prompts us to look for new ways to increase the efficiency of conversion of the chemical energy in fuels to useful heat or work. In the future, new environmental issues will undoubtedly arise. ERL will continue to adapt to meet these new demands. However, environmental problems pose different challenges from those of productivity. Projects oriented toward productivity usually aim for partnership with a small number of organizations that share the commercial benefits of arising intellectual property. In projects that focus on environmental protection we aim to work with groups of organizations that face common problems. The results of these projects are freely available to all. This is one of the most important aspects of our mandate because to stay economically healthy all fossil fuel utilization industries must keep pace with society's demands for a cleaner environment.

D. A. Reeve.

David Reeve

INDUSTRIAL ASSISTANCE AND COLLABORATIVE TECHNOLOGY DEVELOPMENT

ERL offers its clients several avenues for collaboration in its efforts to accelerate technology transfer and promote industrial R&D.

Contract R&D

ERL's clients access about $6M annually toward cost-shared research through CANMET's Energy Conversion Program or by responding to ERL's requests for proposals.

The Energy Conversion Program aims to encourage research in areas that can lead to more effective use of Canada's fossil fuel resources. Proposals, normally ranging from $30K to $600K, are considered for contributions of up to 50% in four categories:

- extraction and recovery of bitumen and heavy oil
- bitumen/heavy oil and natural gas conversion
- synthetic crude distillate upgrading
- coal conversion and utilization

ERL solicits proposals in much the same way that industries obtain outside services. A request for proposal is publicly advertised for services in support of ERL's research program to be provided by industries, universities, and other research establishments. Tenders are reviewed and contracts are awarded on the basis of predetermined criteria. ERL is always willing to meet potential clients to discuss suitable new topics for the Energy Conversion Program or for solicited proposals.

In-house R&D

ERL's annual $13M in-house research program is influenced strongly by industrial participants who ensure that our resources are used effectively to solve industrial problems and to create business opportunities in Canada. ERL offers participation in its program through research consortia, development consortia, and joint agreements.

Research and Development Consortia

In the past year, ERL has joined with industry to form research consortia whose members share the cost and management of longer term research being conducted in our facilities. Research topics for the consortia are determined by consultation with and commitment from potential clients. ERL has formed research consortia to do cooperative research in the following areas: natural gas conversion; distillate refining; heavy oil and bitumen upgrading; and reactive hydrocracking of heavy oils and bitumen. ERL is presently expanding its selection of topics for consortia research and membership is open to all interested parties.

Similarly, CANMET will solicit industrial participation in development consortia that aim to bring technology to a level of commercial acceptance. In 1988/89 ERL formed a consortium to improve the economic viability of the CANMET coprocessing technology.

Joint Projects

ERL's most popular method of interaction with its clients is through joint agreements. These allow ERL to work with industry on a one to one basis, respecting clients' need for confidentiality. Participation can range from 100% cost recovery research to task-shared research. In 1988/89 industry contributed $3.2M toward 74 of ERL's projects.

TECHNOLOGY COMMERCIALIZATION GROUP

The Technology Commercialization Group (TCG) was formed in 1988 to assist ERL staff in business development, communication and program planning. The TCG includes a business development office whose goal is to strengthen ERL's ties with industry and to improve the marketing of ERL's expertise and facilities. Activities include developing research contracts with clients, helping ERL staff negotiate agreements, transferring technology through conferences and seminars, evaluating ERL's business performance, and publicizing ERL's capabilities. Consortia are arranged with industry to share the burden of high-risk R&D as well as the potential benefits. Success in this endeavour is evidenced by the increasing cooperation between ERL and industry and by the integration of ERL's research efforts into industry through shared-cost and cost-recovery projects.

The TCG ensures that federal policymakers are made aware of the technical, commercial and sociological impact of developments in energy and that ERL's scientific papers, brochures, reports and contract documents are presented to the public and to its clients accurately and comprehensibly. The group also evaluates ERL's proposed programs in the context of federal policies and international developments, for example, environmental protection policies. ERL participates through the TCG in national and international energy planning and research bodies such as the Canadian Electrical Association and International Energy Agency Coal Research.

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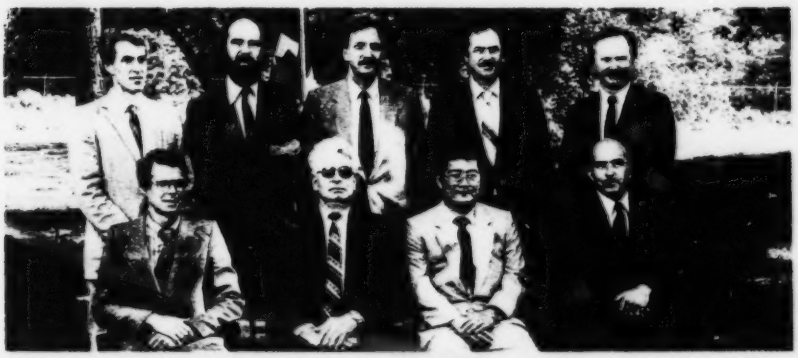
AWARDS

A team of ERL scientists and technologists has developed and transferred to industry a process for upgrading heavy oil, oil sand bitumen, and refinery residuals to distillate. CANMET hydrocracking is being commercialized by Petro-Canada, which demonstrated the process at 5000 b/d under an agreement with EMR. This is the largest oil upgrading R&D effort ever undertaken in Canada. A Group Merit Award was presented to the CANMET hydrocracking team in recognition of its exceptional and distinguished contribution.

Eight members of the Combustion and Carbonization Research Laboratory received a Merit Award for their significant contributions to the Industrial Fluidized Bed Demonstration Program at Canadian Forces Base Summerside, P.E.I. This first application of fluidized bed combustion to coal in Canada was a milestone in the demonstration of new technology for burning high-sulphur coal while controlling emissions that cause acid rain.

Members of ERL's Joint Occupational Safety and Health Committee received the CANMET Award of Excellence for their outstanding work during the past year. Examples of the Committee's significant contributions include development of a waste management policy and disposal procedures; coordination of two chemical waste disposals; development of a safety indoctrination program designed specifically for students; and preparation of a safety manual for ERL employees. Individual awards were presented to David Reeve, Edward McColgan, John Hogan, Mel Maiette, Edward Kowalchuk, Al Lloyd, Luigi Mysak, Jim Whiten, Rob Eagleson, Jim Kelly, Bev Post and Jerry Kriz.



ERL's CANMET hydrocracking team. Back Left: Marten Ternan; Paul Sears; Keith Belinko; Jerry Kriz; Bill Dawson. Front Left: Theo de Bruijn; Jean Denis; Dirkson Liu and Jack Chase. Absent: Rick Logie and Dave Patmore.

CCRL's award-winning team with David Reeve, Director of ERL. L to R: David Reeve; Ben Anthony; Rick Jeffrey; Frank Wigglesworth; Bill Birtch; Dilip Desai; George Lee, Manager; Dan McLaughlin and Vladimir Razbin.

R&D PROGRAM

ERL's research expenditures are directed toward industrial productivity (60%), environmental protection (30%), and policy initiatives (10%). The main thrusts are in advancing new technology from the laboratory to commercial practice and in making current industrial practice more efficient. Most research on new projects is undertaken with industrial sponsorship. Also, ERL's unique facilities are rented to industry when they are not utilized for full time in house work.

Since 1987 substantial progress has been made in achieving closer partnership with the oil, gas, and coal industries. For example, a seminar entitled "CANMET in Partnership with the Oil and Gas Industry" was held in Calgary and attracted about 140 registrants. Our aim is to concentrate on technologies with long-term promise but at a stage of commercial risk too high for industry to tackle alone. The level of private sector commitment is expected to grow as projects approach commercialization.

ERL's goal is to maximize industry's involvement through contracting in research work from private industry to its own laboratories and through contracting out other projects to industry on a shared-cost basis. ERL's resource allocations on each activity are listed below. The rest of this report details ERL's accomplishments in each area of activity.

RESOURCE ALLOCATIONS 1988/89 ($K)

Activity	Operating	Contract	Total
Bitumen and heavy oil recovery	289	1527	1816
Bitumen and heavy oil upgrading	2357	775	3132
Synthetic crude refining and residue utilization	1574	820	2394
Heavy oil and coal coprocessing	2105	350	2455
Natural gas conversion to liquid fuels	757	436	1193
Coal gasification	777	264	1041
Metallurgical fuels	1350	104	1454
Industrial combustion	1552	548	2100
Combustion technologies for pollution abatement	1582	568	2150
Energy and combustion efficiency	1124	403	1527
New utilization and conservation technologies	300		300
Management and support	1000		1000
TOTALS	14 767	5795	20 562

Note: Actual expenditures may differ from those in the above table. For example, following a recommendation from the Minister's National Advisory Council to CANMET, some of the resources allocated to heavy oil and coal coprocessing were shifted to other areas during the year.

ERL's Albert George participates in inspection at AOSTRA's Underground Test Facility. L to R: R.W. Luhning; J.C. O'Rourke, AOSTRA; A.E. George, ERL; W.J. Yurko, AOSTRA.

OIL

RECOVERY OF BITUMEN AND HEAVY OIL

ERL has expanded its program to support external R&D in enhanced oil recovery (EOR) processes for some large conventional oil reservoirs having adverse properties. EOR will be needed to maintain current Canadian oil production through increasing use of heavy oil and bitumen as supplies of conventional oil decline.

Production of Athabasca bitumen by surface mining, as currently practised by Suncor Inc. and Syncrude Canada Ltd, is possible for only about 10% of the oil sands. The remaining 90% must be recovered through in situ technologies (thermal and immiscible displacement processes) that are more environmentally acceptable than surface mining. Also, because of its less extensive capital outlay, in situ recovery is better suited to phased development. Both types of processes, however, can be further developed to improve the recovery of initial oil-in-place.

Highlights

ERL joined with AOSTRA and six oil companies to field test in an underground test facility a successful in situ steam recovery process using horizontal wells. The test results have been very promising and AOSTRA is in the process of expanding this pilot project.

A low-pressure, scaled-down physical simulator was developed to study steam injection strategies in "marginal" reservoirs. The technology was transferred to the Saskatchewan Research Council for field application.

A new concept was developed for recovery of heavy oil and bitumen using vapour-assisted gravity drainage.

ERL participated with several oil companies in a shared-cost program to develop an integrated geotechnical modelling system; generate better reservoir engineering data; study sand control techniques; and investigate several thermal and non-thermal processes for increasing recovery at reduced costs.

McIntyre Engineering Consulting Ltd. prepared a "Five-Year Biotechnology R&D program" for ERL in consultation with the fossil fuel industry. The report recommends that this program be developed by industry, universities and governments collaboratively.

ERL undertook a shared-cost project with industry to field test a novel microbial system in a watered-out heavy oil well reservoir. The work provided valuable information on the reservoir, geology and interwell communications.

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OIL

BITUMEN AND HEAVY OIL UPGRADING

ERL's gamma-ray densitometer is used to measure hydrodynamics in CANMET's hydrocracking demonstration plant.

Current operations rely on coking technologies to upgrade bitumen and Canadian heavy oil, but the trend is shifting towards hydrogen addition or hydrocracking technologies. Since a significant portion of the feed is converted to a coke byproduct that has little value, coking processes are relatively inefficient.

New technologies such as the CANMET hydrocracking process developed at ERL improve liquid yields and product selectivity while minimizing catalyst and hydrogen requirements.

Highlights

ERL has proved the use of a gamma-ray densitometer in its hydrocracking demonstration plant to measure the volumes occupied by gas and liquid, bubble sizes and frequencies, and other hydrodynamic parameters. A major oil company used ERL's world class capabilities to obtain essential engineering data for the scale up of new upgraders.

Large samples of pitch residue from upgrading Canadian heavy oil were pretreated on a cost-recovery basis for a Canadian company for use in the preparation of industrial electrodes for aluminum smelting.

An industrial consortium was formed to study the fundamental chemistry of heavy oil and bitumen upgrading to provide companies with additional insight into their processes and more economical ways to utilize their feedstocks.

New jet reactor technology developed with Sherbrooke University reduces the viscosity of Athabasca bitumen to pipeline requirements without the need for diluent, catalyst or high pressures. Optimization of the process for commercialization is expected to proceed next year.

In partnership with its industrial clients, ERL supported the development of a novel rotating drum coker, the upgrading of water-in-oil emulsions, and the development of vacuum pyrolysis technology to dispose of environmentally unsafe refinery sludges.

For information contact Bill Dawson (613) 996-5298
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Michael Wilson and Craig Fairbridge, research scientists, operate ERL's dual automated hydrotreating unit used in refining synthetic crudes from heavy oil and coal.

OIL

SYNTHETIC CRUDE REFINING AND RESIDUE UTILIZATION

The supply of highly aromatic synthetic crudes produced by advanced primary upgrading processes from oil sands and heavy oil will likely increase. At the same time, new fuel specifications are being proposed in order to improve urban air quality and reduce acid rain.

For diesel and jet fuels, a ceiling will be placed on the content of aromatic hydrocarbons which contribute to smog and particulate emissions from diesel and jet fuels, and the sulphur content will be lowered to 0.05 wt % from 0.5 wt %. Improved cost-effective refining and separation technologies are required to upgrade these fuels. In addition, new developments are needed to ensure greater and better use of the resulting residues.

ERL's research in these areas covers a wide range of processing options involving catalytic hydroprocessing, fluid catalytic cracking, separation processes, surface analysis of catalysts, and characterization of distillates and residues.

Highlights

An R&D consortium was established to support ERL's research in catalytic hydroprocessing of synthetic crudes. The consortium includes members from industry, allowing them to leverage cost of high-risk, long-term research and offering them the earliest opportunity to license the technology being developed.

A joint agreement was established with an outside organization for the fabrication and testing of membranes that have high selectivity for aromatic and saturate fractionation.

A patent was filed for a two-stage process for upgrading synthetic crudes to diesel fuel. Extensive engine testing completed a vital stage of the research and moved the process toward implementation.

A method was devised to extract aromatic components for synthetic crude distillates using a new class of ionic liquids: "liquid clathrates". The process has major advantages over industrial solvent extraction.

A fluid-bed high-temperature steam reactor was designed and successfully operated. The reactor simulates commercial thermal and hydrothermal deactivation of catalysts for fluid catalytic cracking.

A new process was developed for the production of high quality asphalt blends using high conversion CANMET hydrocracking pitch.

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OIL

HEAVY OIL AND COAL COPROCESSING

Bruce Dick, technologist, records data from ERL's bench-scale continuous flow stirred tank reactor coprocessing unit.

Coprocessing, the simultaneous processing of coal and oil to upgrade the oil and liquefy the coal, is especially suited to Canada since coal and oil resources exist close together. ERL's coprocessing program emphasizes partnership with industry and cooperation with other research organizations having similar aims.

A combination of coal liquefaction and heavy oil upgrading, coprocessing has substantial advantages over both. Compared with coal liquefaction, it can eliminate process-derived recycle solvent. Compared with hydrocracking, it can increase operating margins by replacing expensive heavy oil with lower cost coal. Through research on catalyst development and reactor design, ERL aims to make use of these advantages to increase reactor throughput and lower operating cost.

Depending on the combination of oil and coal, benefits may occur because of the coal's capacity to adsorb heavy metals and any coke formed during the reaction. Further, the potential exists for synergy in terms of increased process yields due to interaction of the coal and oil.

Highlights

Under a memorandum of understanding between EMR and the US Department of Energy (DOE), an implementing agreement on coprocessing R&D was signed between ERL and DOE. The Alberta Research Council will also participate in this agreement.

ERL participated in organizing a symposium on coprocessing at the Third Chemical Congress of North America, Toronto, June 1988. The symposium included three sessions and the papers were published in a special issue of Energy and Fuels.

An industrial R&D consortium is being formed to further develop coprocessing. Negotiations are being carried out with a large oil company and a coal conglomerate. ERL will be the operating laboratory of the consortium. The objective is to generate an engineering database to be used for the design of a larger scale pilot plant. The technical program for the first phase of the consortium operations addresses feedstock flexibility, reactor behaviour and product characterization.

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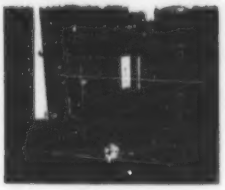

ERL's dual-bed reactor system is used for natural gas conversion studies.

GAS

NATURAL GAS CONVERSION TO LIQUID FUELS

ERL's research facilities for investigating catalytic natural gas conversion are modern and versatile. The specialists who operate this equipment have many years of research experience.

Canada's natural gas reserves exceed current requirements for export and for domestic uses (heating fuel, feedstock for hydrogen in chemical plants and methanol). Potential uses that could be created by ERL's research in natural gas conversion include:

- transportation fuels (gasoline)
- petrochemical feedstocks (ethylene)
- higher molecular weight gases (ethane, propane), which would be less expensive to transport than methane on a unit weight basis

Highlights

ERL has developed a new process for conversion of methane to iso-butylene using a catalyst with a remarkably high selectivity for iso-butylene formation. Iso-butylene is an important feedstock for the chemical industry and is one of the feedstocks for the octane enhancer, methyl tertiary butyl ether.

An agreement was signed with the first industrial sponsor for an exploratory research consortium on natural gas conversion. The aim of this consortium is to bring together process developers, catalyst manufacturers, and end-users to guide ERL's exploratory program on natural gas. While providing a high leverage ratio to each participant, this consortium will foster inputs from key participants to enhance the probability of success and shorten the time for process development and for transfer of technology from ERL to the private sector.

Construction of a new reaction system for conversion of natural gas via oxidative coupling was completed. Ethylene is one of the major products from this process. Additional experimental studies on this process have been contracted out to the Institut de recherche d'électricité du Québec/Gaz Métropolitain and to the Alberta Research Council.

Work on methane-olefin reactions has been contracted out to Guelph Chemical Laboratories and to the University of Ottawa. Products from these reactions are higher molecular weight species.

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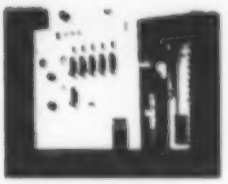
COAL GASIFICATION



Quench part of entrained bed gasifier.

ERL's research in coal gasification has two goals: to help industry select and develop the best technologies for integrated gasification-combined cycle generation (IGCC) of electricity and to evaluate the gasification potential of coals in Canada. IGCC is one of the most important avenues for improving efficiency in energy conversion, thereby reducing emissions of greenhouse gases. Gasification technology, with the possibility of converting any solid organic material to gaseous fuel, is a valuable tool for Canada's energy future.

The Coal Gasification Technical Committee, a working group drawn from the private sector, provincial research agencies and the federal government, has asked ERL to play a lead role in coordinating Canadian studies on coal gasification properties to ensure an integrated effort in gasification research.

Japan plans to use coal gasification for producing hydrogen and electricity and is considering the use of gasifier products for reduction of iron ore. These developments could increase substantially exports of Canadian coals.

Highlights

A joint study was undertaken with the Canadian Electrical Association to assess the feasibility of generating electricity (cleanly) by using integrated gasification-combined cycle technology.

The Coal Gasification Technical Committee completed the first phase of evaluation of Canadian coals for gasification. A "Databank of Western Canadian Coals for Gasification" was prepared.

The construction of a 5 to 20 kg/hr entrained bed pilot plant was completed. The unit will be used to gasify Canadian coals and other nonreactive feedstocks for industry on a cost-recovery basis.

A series of correlations based on petrographic data was developed to predict coal reactivity. This joint effort was undertaken with the Institute of Sedimentary and Petroleum Geology of the Geological Survey of Canada and the Alberta Research Council.

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Coke being discharged from pilot plant coke oven.

COAL

METALLURGICAL FUELS

Canada's coking coal trade (28 million tonnes for export and 6 million tonnes for domestic markets annually) relies heavily on ERL's internationally recognized test facilities for the assessment of metallurgical coals' coking qualities. These facilities, which are run cooperatively with industry through the Canadian Carbonization Research Association, allow development of improvements in the quality of coke from lower grade coals, and formulation of blends using Canadian coals for cokemaking.

Conventional international test methods tend to underestimate the coking quality of Western Canadian coals. ERL is currently developing new tests which will demonstrate the high quality of these coals, and enhance the competitiveness of the industry.

Highlights

Twelve cost-recovery projects were completed for industry. These included evaluation of new coal seams and coal products, selection of coking blends, and provision of advice and consulting services.

ERL showed that mild oxidation, which occurs during coal storage, can adversely affect hot strength properties of cokes. Methods to determine the boundary between metallurgical and thermal coal were examined and a tentative test method is now being assessed. It was demonstrated that variable peak pressure in industrial coke ovens is caused by vertical temperature gradients. Results from two coal preparation plants showed that, although fine coal is high in reactive macerals, large amounts in the final product decrease the quality of coke.

A pilot-scale test rig for evaluating the efficiency of coal injection into blast furnaces was designed and is being built.

A start was made on the assembly of a completely automated petrographic analysis system.

A novel cokemaking method, which has less impact on the environment, is being evaluated.

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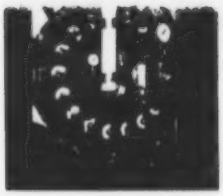
COAL

INDUSTRIAL COMBUSTION



ERL's oil/coal water fuel burner is now installed in Maritime Electric's No. 10 unit oil designed utility boiler at Charlottetown.

Canadian coal users and suppliers participate in ERL's combustion research program. ERL has internationally recognized test facilities and knowledge to assess combustion characteristics for any fossil fuel. As amply demonstrated by industrial and utility demand over the past ten years, users need such data to conduct operations successfully. ERL fulfills the needs of coal users moving from premium fuels to indigenous, lower-quality coals. Often these coals are from newly developed seams for which reliable data on combustion, emission characteristics, and heat transfer are not otherwise available. Performance data for 15 coals were summarized and published as a CANMET report in 1989.

New coal utilization technologies such as coal liquid mixtures (CLM) and micronized coal that allow easy, economic handling with minimal environmental impact are viable options for using coal in oil-designed furnaces. As a replacement for No. 6 oil in existing units, CLM would avoid many of the costs of burner retrofit and on-site coal storage, handling and preparation associated with conventional pulverized coal technology.

Through ERL, Canada joined nine other countries in an International Energy Agency (IEA) Agreement on Coal Combustion Sciences to exchange research results on coal reactivity, flame diagnostics and ash fouling properties under task- and shared-cost agreements. One such agreement has been extended by two years to characterize coal blends and scale up a low NO_x combustion burner. ERL also participates in an IEA information exchange on CLM which accesses the latest data on large-scale demonstrations in Italy and Japan.

Highlights

ERL developed an industrial coal water fuel burner which incorporates a National Research Council of Canada (NRC) ceramic atomizer. Novel features include dual fuel (oil or coal water) capability, 30-80 GJ/h capacity, excellent flame stability and little atomizer wear. The burner was demonstrated in Maritime Electric's oil-designed 20 MWe No. 10 Unit and in Minas Basin Pulp and Power's 15 MWth boiler. ERL is currently scaling up this burner from 17 to 50 MWth in association with two Maritime utilities and, in cooperation with NRC, is investigating ceramic materials that will resist wear and thermal shock.

As part of its CLM combustion research, ERL has conducted a number of combustion tests to demonstrate the more benign combustion performance and ash behaviour of coals when burned conventionally (pulverized combustion) or as CLMs.

Several pitch residues from oil upgrading were investigated to determine their suitability for combustion by conventional suspension firing in a joint project with AOSTRA, CANMET, six oil companies and an electric power utility.

A technique is being developed to measure the gas temperature and species concentration in a furnace or flue gas stream without disturbing the test section. This technology can be applied to low quality fuel combustion studies and pollution abatement strategies.

For information contact Horace Whaley (613) 996-7932
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COAL COMBUSTION TECHNOLOGIES FOR POLLUTION ABATEMENT

The Chatham Circulating Fluidized Bed Demonstration Project – cosponsored by New Brunswick Electric Power Commission.

In participation with Canadian industry, ERL is actively pursuing technically reliable and economic pollution abatement alternatives for a wide range of energy conversion technologies. One major thrust is in fluidized bed combustion (FBC). ERL has FBC facilities for testing a wide range of fuels at atmospheric pressure. Performance data have been derived for high-sulphur Maritime coals, high-moisture plains coals, oil sand upgrader cokes, and hydrocracking pitch residues. Through ERL, Canada participates with 12 other countries in the IEA information exchange agreement on atmospheric FBC, providing a valuable source of research information to industry.

Highlights

A burner demonstration at Canadian Forces Base Gagetown, N.B. resulted in the successful reduced NO_x and SO_x emissions by 50% using eastern Canadian coal. An associated reduction of 50% in distillate oil use and an increase in boiler efficiency realized fuel savings of more than $50K per year. ERL's leadership was acknowledged when the Department of National Defence formally accepted the retrofitted system in June 1988.

In Canada's first demonstration of FBC technology at Summerside, P.E.I., tube erosion and wastage of pressure parts were eliminated by low-cost protective hardware replacing exotic materials. A U.S. patent was issued on ERL's fly ash reinjection system.

The 22 MWe circulating FBC Boiler Demonstration at Chatham, N.B. achieved 90% sulphur capture with a calcium to sulphur ratio of about 2:1. ERL's participation in this demonstration, using Nova Scotian coal, substantially assisted Nova Scotia Power Corporation in specifying details for a 150 MWe circulating fluidized bed power station.

A technical assessment (including sulphur capture) of the TransAlta slagging burner using high-sulphur bituminous coal was made for the Canadian Electrical Association.

ERL developed a technique for determining unburned carbon in combustion residues and collaborated with electric utilities to measure N_2O stack emissions at 11 Canadian power stations and study limestone injection to control SO_2 emissions from utility boilers using Alberta subbituminous coal. N_2O emissions were found to be close to the threshold of measurement and not to be a problem. The limestone injection studies were used as a basis for a three-year cooperative research program.

Mathematical models were developed jointly with private, provincial and federal organizations to clarify the effects of various parameters on acid rain precursors, and to design boilers for optimum performance through the IEA Agreement on Atmospheric FBC.

Advice on effective additives was provided to a Canadian electric utility on the risk of superheater tube failures during long-term combustion trials with oil-water emulsions.

A cost-recovery contract was completed for the conceptual design of a coal combustion research facility for a thermal power research institute in China. Chinese engineers were trained in the use and maintenance of automated flue gas analytical systems.

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CONSERVATION, ENERGY AND COMBUSTION EFFICIENCY

Advanced technology woodstove under test at CCRL.

ERL is actively developing more efficient fuel utilization technology for residential, commercial and industrial applications, through improved combustion, optimization of operational conditions, and integration of improvements into new energy systems such as cogeneration and district heating or cooling. The efficient use of fuels increases productivity, lowers operating costs and reduces pollutant emissions including carbon dioxide emissions, the dominant force in the 'greenhouse effect'.

Fuel switching from fossil fuels to wood waste and other biomass-derived fuels for direct combustion is being aggressively pursued by the Canadian forest products industry and other industrial energy consumers in those regions of the country where fossil fuels are at a premium. In the residential sector, wood-burning appliances now account for a significant fraction of energy requirements of the same order as oil in many regions. ERL's program includes development of retrofit techniques and combustion technology to improve the combustion performance of installed units by making them cleaner, safer and more efficient. Assuming proper forest management, biomass combustion has the potential to reduce emission of greenhouse gases, because of the closed carbon cycle it entails.

Highlights

Guidelines have been developed on fuel oil quality to allow refiners to maximize the crude oil barrel and ensure good field performance. This industry-wide activity will result in changes to the Canadian General Standards Board's national fuel oil specifications. ERL has carried out contracts for two major oil companies to examine performance of proprietary fuels.

Development of safe venting of combustion equipment to ensure good indoor air quality, even in airtight houses, has resulted in major changes to Canadian building and appliance installation codes and practices. ERL has developed combined space and water heating systems that offer potential for significant overall fuel savings and are more compatible with the energy demands of newer houses.

Field trials on advanced wood-burning appliances in Whitehorse, Y.T. and the northern U.S.A. have shown that new technologies can reduce emissions and improve efficiency. ERL's new combustion designs and guidelines promise to reduce emissions by 50 to 70%.

Trials on combustion of artificial fire logs in conventional fireplaces showed that this fuel can reduce emissions significantly and should be used where pollution is a problem. These trials have enabled the fuel manufacturer to achieve significant export sales.

New standards written for the Canadian Standards Association by ERL specify emission levels from appliances and allow the use of wood-burning appliances in airtight houses.

Ice slurry technology, including the development of friction-reducing additives, is showing high economic feasibility for district cooling applications.

Nonazeotropic fluids have been identified to improve heat pump efficiency and to replace chlorofluorocarbons, the principal contributors to ozone depletion.

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ENERGY DIVERSIFICATION

The Energy Diversification Research Laboratory (EDRL) is a new laboratory which is being established in Varennes, Quebec. Activities concentrate on new, environmentally sound technologies related to energy utilization and conservation. EDRL's research mandate ranges from energy system components, such as heat pumps and energy storage, to energy carriers such as hydrogen.

Heat pump research will start by assessing replacement fluids for ozone-damaging chlorofluorocarbons, then go on to optimizing component designs and developing novel energy systems. Energy storage research will concentrate on the performance evaluation of advanced thermal storage materials, advanced battery developments and on system design and optimization.

Investigations will be conducted on the production of alternative fuels from natural gas and the generation of hydrogen from both natural gas and liquid fuels for possible use in fuel cells. The increased utilization of natural gas for energy purposes will produce a positive environmental impact because of reduced emissions of carbon dioxide per unit of energy produced. Fuel cells can produce similar results owing to improved energy conversion efficiencies. The establishment of a national fuel cell test facility is a related objective.

Research on biomass will focus on waste materials derived from municipal, industrial and agricultural processes since they represent a source of renewable energy and their disposal creates environmental problems. Research will be undertaken to determine the effects of various processing conditions on the physical and chemical characteristics of biomass materials and on the development of novel preparation and conversion processes.

ERL took responsibility for the early phases of the establishment of EDRL during fiscal year 1988/89. EDRL is now a component of CANMET's Efficiency and Alternative Energy Technology Branch. The resources allocated for fiscal year 1989/90 are $1.7M and 9 person years.

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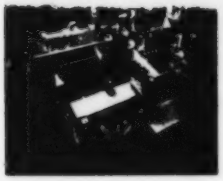
FUEL CHARACTERIZATION



Mini reactor developed at ERL permits treatment and monitoring of reactants and products under simulated process conditions. A commercial scale version of the prototype, which was licensed to a Canadian company, has now realized industrial sales.

As supplies of conventional fossil fuels decrease, industry will have to accommodate off-specification fuels from nonconventional supplies. Consequently, ERL's ongoing efforts in the evolution and standardization of test methods and specifications and in the development of novel methodology, instrumentation, and quality and process control procedures are essential.

ERL participates with industry and standards writing organizations in the development, implementation, maintenance and dissemination of fossil fuels standards. ERL initiates and participates in the development of novel methodology and remote chemical sensing techniques in support of demonstrations of SO_x and NO_x control technologies, determining gasification characteristics of Canadian coals, residue utilization and distillate upgrading.

Highlights

Twenty-three laboratories from Canada and the U.S.A., including five producers, five users from the industrial sector, and thirteen referee laboratories, participated in a petroleum coke sample exchange initiated under CANMET's Service Program for Evaluation of Codes and Standards (CANSPECS).

ERL participated with the Coal Association of Canada in presenting to the United Nations Economic Commission for Europe (ECE) Canada's position on the proposed ECE international classification for coal. As a result, a standard that misrepresented Canadian coal was put on hold.

Together with the Canadian General Standards Board, the National Research Council of Canada, the Petroleum Association for Conservation of the Canadian Environment, and the Alberta Research Council, ERL participated in an assessment of the impact of current and future fuels on diesel and gasoline engine emissions.

A briefcase-sized container was licensed to a Canadian company to allow shipment of sensitive solid specimens between ultrahigh vacuum chambers. The unit can be adapted for use on surface science equipment.

ERL led the development of a performance standard for capillary columns used in the petroleum and petrochemical industry for hydrocarbon separation.

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